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ORIGINAL ARTICLE

The EUROP total knee prosthesis: A ten-year follow-up study of a posterior cruciate-retaining design

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KEYWORDS
Total knee arthroplasty;
Fixed bearing tibial implant;
Posterior cruciate ligament;
Long Term outcomes

Summary
Introduction: The success of total knee arthroplasty is measured by pain relief, functional recovery, and implant survival duration.

The aim of the present study was to evaluate the long-term clinical, functional and radiological results of the posterior cruciate ligament (PCL)-retaining fixed bearing EUROP implant.
Hypothesis: The long-term results of EUROP implants are similar to those reported with comparable prostheses.
Patients and methods: We performed a prospective, monocentric study of a series of 121 cemented EUROP total knee arthroplasties, implanted between 1994 and 1996 in 117 patients mean age 73. A clinical and radiological evaluation was performed at 10 years of follow-up according to the International Knee Society (IKS) score. Twenty-three patients died, 14 were lost to follow-up, 43 underwent clinical and radiological evaluation and 37 were questioned by telephone.
Results: The preoperative IKS knee score was 31 points (0—60) and increased to 88 points (30—98) at final follow-up, IKS function increased from 40 (0—90) to 80 points (25—100). Radiolucencies were observed in 56% of the condyles and 60% of tibial plates. Ninety-three percent of these radiolucent lines were less than 1 mm wide. Three patients underwent revision TKA at 32 months, eight and 11 years respectively. Global implant survival was 99% at five years, 97.8% at 10 years and 95.8% at 12 years.
Discussion: The clinical and radiological results of the cruciate-retaining fixed bearing EUROP total knee arthroplasties, with three cases of revision arthroplasty at 12 years of follow-up are satisfactory and comparable to similar implants.
Level of evidence: Level IV; prospective study.

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Introduction

Total knee arthroplasty (TKA) is effective for osteoarthritis of the knee when functional difficulties and pain do not respond to medical treatment. Pain is the most common symptom for an indication of total knee replacement. By relieving pain and restoring mobility to the knee, TKA improves the patient's quality of life [1].

The success of total knee arthroplasty is evaluated by the amount of pain relief, functional recovery and implant survival. Several factors may play a role and reduce implant survival: poor positioning of components, wear and osteolysis which mainly results in implant loosening.

The aim of our study was to evaluate the long-term clinical, functional and radiological results of the PCL-retaining, fixed bearing tibial plate EUROP prosthesis (EUROS SAS La Ciotat, France). We hypothesized that this prosthesis would provide satisfying results, which would be comparable to those in the literature for similar prostheses.

Patients and methods

Population

Between January 1994 and December 1996, we performed a prospective, monocentric study of a series of 174 TKA in 166 patients operated on by a single surgeon. Patients were included if they received the PCL-retaining EUROP prosthesis in the absence of insufficient medial and/or lateral ligament on one hand and in the absence of ligament laxity due to PCL injury on the other hand. Preoperative medial and lateral reducibility was systematically tested with the Telos device for frontal plan deformities. The final decision to use this PCL-retaining prosthesis was made intraoperatively if the central pivot was intact (except in one case with an isolated tear of the ACL) and successful flexion-extension gap balancing. Exclusion criteria included (1) postero-stabilised prostheses and (2) cementless, hybrid prostheses. The choice to use this implant was based on the preoperative radiological and clinical evaluation.

The total study population included 121 knees (117 patients), including 73 women and 44 men, mean age 73 ± 5 years old (59—87) (mean body mass index $29 \pm 4\,kg/m^2$ [18—42 kg/m^2]).

The preoperative diagnosis was primary osteoarthrtitis of the knee in 84.3%, osteoarthritis secondary to ligamentary or bone trauma in 3.3%, osteoarthritis secondary to rheumatoid polyarthritis in 2.5% of cases, osteonecrosis in 5.8%, and revision surgery for a unicompartmental implant in 4.1%.

There was no history of surgery in 77% of the knees. There was a history of tibial osteotomy in 12 cases, five unicompartmental implants, two anterior tibial tuberosity transpositions, five meniscectomies, two popliteal cysts, one ligamentoplasty, and one arthroscopic lavage. According to the Insall classification [2], 39% of patients were classified A, 57% B and 4% C.A varus deformity ($9 \pm 5^\circ$ [2—31°]), was present in 66.4% of knees a valgus deformity ($9 \pm 4^\circ$ [2—20°]) in 23.3% and alignment was normal in 10.3%. Twenty-eight percent of the knees had a frontal plane deformity between 0 and 5°, 39% between 6 and 10°, 27% between 11 and 15°, and 6% of at least 16°.

Figure 1 EUROP prosthesis (EUROS).

Patients were evaluated prospectively. The mean duration of follow-up was 9 ± 4 years (1 month—14 years). At a mean follow-up of five years (3—7 years), 11 patients (11 knees) had died, 12 patients (13 knees) were lost to follow-up, 72 patients (75 knees) underwent a clinical evaluation and 22 patients (22 knees) were questioned by telephone. At a mean follow-up of 10 years (8—12 years), 23 patients (24 knees) had died, 14 patients (15 knees) were lost to follow-up, 43 patients (45 knees) underwent a clinical and radiological follow-up. Thirty-seven patients (37 knees) were questioned by telephone, mainly because of their age and/or various associated diseases making it impossible for them to come to a follow-up consultation.

EUROP Version 1® prosthesis

The chrome cobalt femoral component has a symmetric condyle with varying radii without a reconstruction cage (Fig. 1). The titanium tibial component has a bi-block base without a reconstruction cage where the fixed liner can be snapped into place. The ultra high molecular weight polyethylene (UHMWPE) liner is moulded. The liner has two slight anterior and posterior raised areas, 2 mm for small sizes and 3 mm for average and large sizes. A liner of at least 9 mm thick was used in 91% of implants. The polyethylene patellar plate has a peg for cement fixation. The patella was resurfaced in 93% of cases. Implants were sterilized by gamma radiation in air. All tibial, femoral and patellar components were cemented and fixed with polymethylmetacrylate cement.

Surgical technique

The surgical technique was similar in all cases. An anterior surgical approach was used with a median parapatellar and transquadriceps arthrotomy. The initial tibial incision was performed with an extramedullary cutting guide, to retain

the PCL and leave its insertion intact. The distal femoral incision was performed with intramedullary targeting and was perpendicular to the mechanical axis of the femur. A tourniquet was used during one-stage cementing. Additional surgical procedures were necessary in 10 knees: removal of valgus tibial osteotomy material in four cases, partial freeing of the medial ligament in two cases, one varus femoral osteotomy, one osteotomy of the anterior tibial tuberosity, one release of the lateral retinaculum, and one tibial bone filling due to a large cavity in the posterior medial tibial plate.

All patients received antibiotic and thromboembolic prophylaxis.

Clinical evaluation

The clinical evaluation was based on the International Knee Society (IKS) score [2]. Measurements of articular range of motion were obtained by goniometry.

Implants requiring surgical revision and patients with functional incapacity due to osteoarthritis of the controlateral knee or hip were not excluded from the study.

Radiological evaluation

Preoperative standard weight-bearing AP and lateral X-rays as well as long leg X rays were obtained to measure mechanical and anatomical axes. We evaluated correction of deformities at 10 years of follow-up. All measurements were performed with IMAGIKA software (View Tec, Saint-Maurice, France).

Radiolucencies [3] and osteolytic zones were noted. The actual size of radiolucencies was calculated by determining the ratio between the radiolucent line and the size of the implants. X-rays were evaluated under blind conditions by a surgeon who was not involved in the clinical follow-up of the patients. Because an axial view of the patella was not systematically obtained, a radiological evaluation of patellar radiolucencies was not performed.

Statistical analysis

Quantitative variables were compared by the Wilcoxon test for paired series or the Mann Whitney test for independent samples. The Pearson coefficient was used for correlations. Tests were bilateral with a risk of Type I error of 5%. Implant survival was calculated by the Kaplan-Meier method with a confidence interval of 95%. The probability of implant survival was calculated by defining failure as partial or total implant revision, for whatever the cause.

Statistical analyses were performed by an independent statistician[1] with SAS version 9 software (SAS Institute Inc., Cary, North Carolina, USA).

Results are expressed as median values with a maximum-minimum range.

[1] AtlanStat, France.

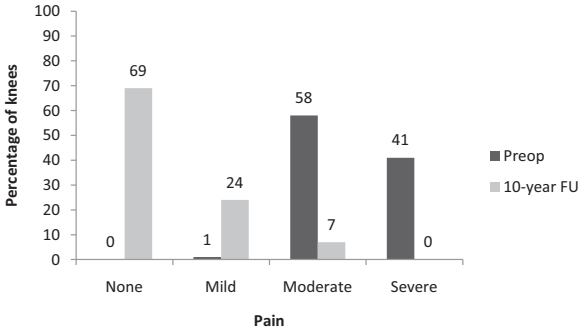

Figure 2 Distribution as percentage of patients in relation to the pain score before and 10 years after the arthroplasty.

Results

Complications

There were six cases of deep venous thrombosis, one pulmonary embolism (which was not lethal), one stroke, 13 cases of stiffness requiring manipulation under general anesthesia, three postoperative hematomas, and one patellar dislocation. There were no superficial or deep infections.

The cases of stiffness required manual manipulation under general anesthesia, which was performed within a median of 34 days (28—56 days). For these knees, median flexion was 75° (35—90°) before manipulation, 95° (70—120°) at three months of follow-up and 100° (90—120°) at one year. Two patients who underwent manipulation had a complex regional pain syndrome. No secondary arthrolysis or implant revision surgery was necessary in this group.

Clinical evaluation

Knee score

The median knee score was 31 points (0—60) preoperatively, 88 points (58—100) at five years and 88 points (30—98) at 10 years of follow-up ($P < 0.0001$; Table 1). There was no deterioration in the knee score between the 5- and 10-year follow-up ($P = 0.55$).

Pain. The median pain score was 10 points (0—40) preoperatively and 50 points (10—50) at 10 years of follow-up ($P < 0.0001$; Table 1): 69% of patients had no pain, 24% of patients had minimal pain and 7% moderate pain (Fig. 2). None of the patients had severe pain at 10 years of follow-up.

Flexion. The median flexion was 120° (80—140°) preoperatively and 110° (80—125°) at 10 years of follow-up ($P < 0.01$; Table 1): 88% of patients had a knee flexion angle of at least 100°.

Patients were divided into two groups according to their preoperative flexion ($\leq 100°$ for group 1; $> 100°$ for group 2; [$P < 0.001$]) (Fig. 3). The frequency of manual manipulation under general anesthesia was not statistically different between the two groups (Fisher test, $P = 0.7$). In group 1, flexion increased from 90° (80—100°) to 100° (80—115°) at 10 years of follow-up ($P = 0.06$). In group 2, flexion decreased from 120° (105—140°) to 110° (80—125°) at 10 years of follow-up for a significant mean loss of 10.6° ($P < 0.0001$)

Table 1 Clinical results at the preoperative visit and at the 5- and 10-year follow-up visits.

	IKS	Preoperative visit	5-year FU visit	10-year FU visit
Function score (/100 points)	Mean ± Std	43.3 ± 22.6	83.7 ± 17.2	76.3 ± 21.6
	Min/Max	0/90	30/100	25/100
	Median	40	90	80
	Wilcoxon test		$P < 0.0001$[a]	$P < 0.0001$[b]
Walking (/50 points)	Mean ± Std	25.8 ± 9.7	43.6 ± 10.7	43.3 ± 9.9
	Min/Max	10/50	10/50	20/50
	Median	20	50	50
	Wilcoxon test		$P < 0.0001$[a]	$P < 0.0001$[b]
Stairs (/50 points)	Mean ± Std	20.4 ± 14.1	41.2 ± 7.5	34.3 ± 13.4
	Min / Max	0/50	30/50	0/50
	Median	15	40	30
	Wilcoxon test		$P < 0.0001$[a]	$P < 0.0001$[b]
Deductions of the function score (minus) (/20 points)	Mean ± Std	−3.3 ± 3.9	−1.1 ± 2.9	−1.8 ± 3.4
	Min/Max	−20/0	−20/0	−20/0
	Median	−5	0	0
	Wilcoxon test		$P < 0.0001$[a]	$P < 0.0002$[b]
Knee score (/100 points)	Mean ± Std	32.1 ± 12.7	86.4 ± 9.3	84.9 ± 12.8
	Min / Max	0/60	58/100	30/98
	Median	31	88	88
	Wilcoxon test		$P < 0.0001$[a]	$P < 0.0001$[b]
Pain (/50 points)	Mean ± Std	7.1 ± 7.1	47.1 ± 7.4	45.9 ± 10.1
	Min/ Max	0/40	10/50	10/50
	Median	10	50	50
	Wilcoxon test		$P < 0.0001$[a]	$P < 0.0001$[b]
Flexion (degrees)	Mean ± Std	114.1 ± 14.0	110.9 ± 11.6	107.2 ± 10.4
	Min/Max	80/140	80/140	80/125
	Median	120	110	110
	Wilcoxon test		$P < 0.05$[a]	$P < 0.01$[b]
Medio-lateral stability (/15 points)	Mean ± Std	10.2 ± 4.7	14.5 ± 1.7	14.2 ± 1.8
	Min/Max	0/15	5/15	10/15
	Median	10	15	15
	Wilcoxon test		$P < 0.0001$[a]	$P < 0.0001$[b]
Antero-posterior stability (/10 points)	Mean ± Std	9.9 ± 0.7	10.0 ± 0.0	9.9 ± 0.7
	Min/Max	5/10	10/10	5/10
	Median	10	10	10
	Wilcoxon test		n.s.[a]	n.s.[b]
Deductions of the knee score (minus) (/50 points)	Mean ± Std	−18.9 ± 9.6	−7.3 ± 6.1	−6.7 ± 7.2
	Min/Max	−40/0	−20/0	−20/0
	Median	−20	−9	−4.5
	Wilcoxon test		$P < 0.0001$[a]	$P < 0.0001$[b]

Std: standard deviation; Min: minimum; Max: maximum: FU: follow-up.
[a] Result of the Wilcoxon test between the preoperative visit and the 5-year follow-up visit.
[b] Result of the Wilcoxon test between the preoperative visit and the 10-year follow-up visit.

(Fig. 3). There was no significant difference between the two groups at 10 years of follow-up ($P = 0.097$).

Function score

The median function score went from 40 points (0—90) preoperatively to 90 points (30—100) at five years and 80 points (25—100) at 10 years of follow-up respectively ($P < 0.0001$; Table 1). The decrease in the function score between five and 10 years of follow-up was statistically significant ($P < 0.01$).

The different items of the function score are presented in Table 1.

Statistical analysis

No correlation was found between the categories of patients (A, B or C), the age at surgery, the body mass index or the clinical results at 10 years of follow-up.

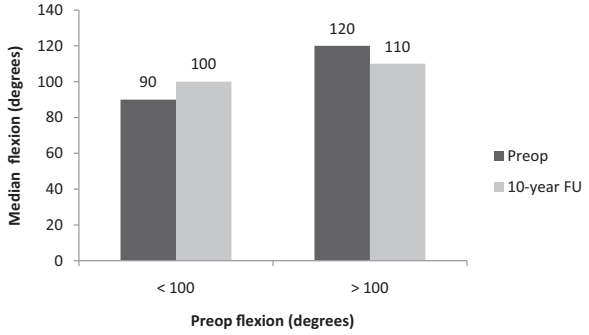

Figure 3 Median values of postoperative flexion in relation to preoperative flexion expressing the difference between the knees with a flexion less or equal than 100° and those with a flexion greater than 100°.

Radiological evaluation

Position of implants. At 10 years of follow-up, the tibiofemoral anatomical axis was 176° (interquartile interval 174—178°). Sixty-seven percent of the patients had a tibiofemoral axis between +3 and −3°, 83% between +4 and −4°, 89% between +5 and −5° respectively. Eleven percent of the patients had residual varus of between 6 and 7°. The anatomical angle (α) of the femur was 95.1° (interquartile interval 93.9—96.2°) and the anatomical angle (β) of the tibia was 88.8° (interquartile interval 87.8—90.6°). The femoral angle at flexion (γ) was 4.9° (2.8—6.9°) and the tibial slope (σ) was 5.5° (3.5—7.2°).

Radiolucencies. Fifty-six percent of the knees presented with femoral radiolucencies, 49% and 33% with tibial radiolucencies on AP view and lateral view X-rays respectively (Table 2). Radiolucencies were no larger than 1 mm in 96.5% of femoral lucencies, 88% and 100% of AP and lateral view tibial radiolucencies, respectively (Table 3). Most femoral radiolucencies were found in zones 1 and 4 (Fig. 4) and tibial radiolucencies in zones 1 and 2 (Fig. 5A and B). All of the implants had a radiological score of 4 or less by the Ewald method. None of these radiolucencies required surgical revision.

Osteolyses. Five knees presented with osteolyses. Two of these knees required revision surgery, one at eight years and another 11 years.

Analysis of implant survival

The global rate of implant survival was 99% (93.1%—99.9%) at five years, 97.8% (91.5%—99.5%) at 10 years and 95.8% (87.1%—98.7%) at 12 years respectively (Fig. 6) when revision

Table 2 Percentage of knees exhibiting radiolucent lines in relation to the number of zones affected.

		Percentage of knees		
		Femur	Tibia - AP view	Tibia - Lateral
Number of zones affected	0	44	51	67
	1	36	16	27
	2	20	18	6
	3	0	11	0
	4	0	4	0

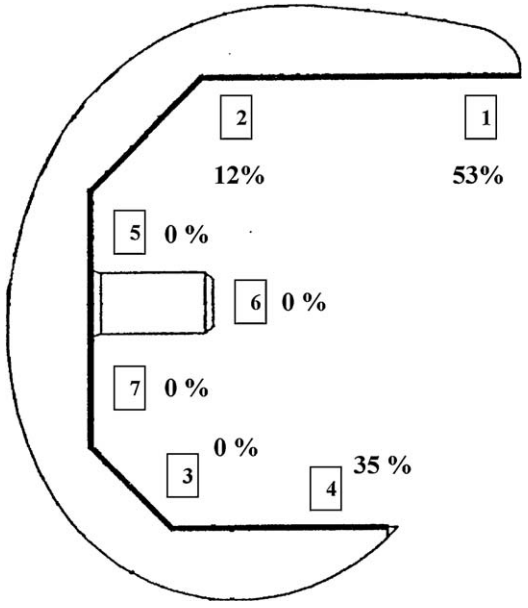

Figure 4 Distribution of femoral radiolucent lines at 10-years post-op.

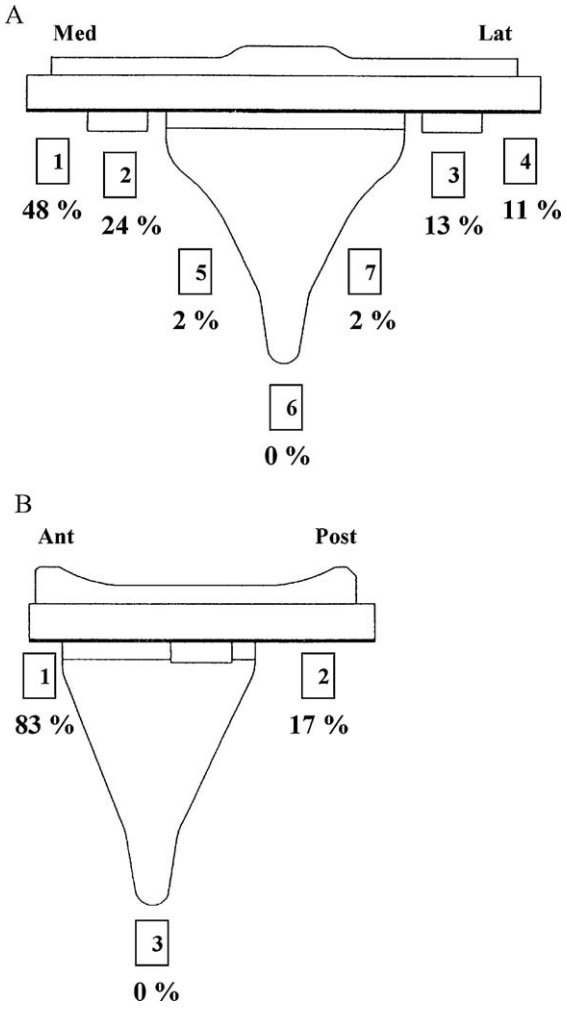

Figure 5 Distribution of radiolucent lines in relation to the AP view (A) and lateral view (B) tibial tray, at 10-years post-op.

Table 3 Percentage of knees exhibiting radiolucent lines in relation to the size of the radiolucent lines (RLL).

		Percentage of knees		
		Femur	Tibia - AP view	Tibia - Lat view
Size of RLL	≤ 0.5 mm	53.5	55	38
	$0.5 < \text{Size} \leq 1$ mm	43	33	62
	$1 < \text{Size} \leq 1.5$ mm	3.5	9	0
	> 1.5 mm	0	3	0

implant surgery was used as the criteria. Three surgical revisions were performed postoperatively at 32 months, eight years and 11 years, respectively (the patellar plate was changed and the patellar tendon repaired because of full tear of the extensor apparatus in an obese patient; revision due to loosening of the femoral condyle on extensive osteolysis of the medial condyle without significant wear to the polyethylene in one patient with rheumatoid polyarthritis; and loosening of the condyle and tibial base with medial wear to the polythelene). When the three cases of non-operated radiological failure are included, implant survival was 99% (93.1%—99.9%) at five years, 94.9% (86.8%—98.0%) at 10 years and 91.3% (81.3%—96.0%) at 12 years respectively.

Discussion

The aim of this study was to evaluate the long-term radiological, functional and clinical results of the EUROP total knee arthroplasty compared to results in the literature for similar fixed bearing PCL-retaining implants.

Systematic preservation of the PCL was not possible and depended upon preoperative planning on one hand and intraoperative conditions on the other. Only patients with an intact central pivot and without medial and/or lateral ligament damage were selected for this study. However, the final decision to preserve the PCL was only made if the medial flexion gap was respected above 90° without performing tibial (respecting the anatomical slope and frontal axis) or femoral incisions (increase of external femoral rotation).

As in many studies on arthroplasty in elderly patients, this long-term study is affected by the number of lost to follow-up and patients who cannot be evaluated because of various associated diseases. However, patients who could not travel to a follow-up consultation were questioned by telephone and general practitioners were also questioned to determine the status of implants if the patient had died.

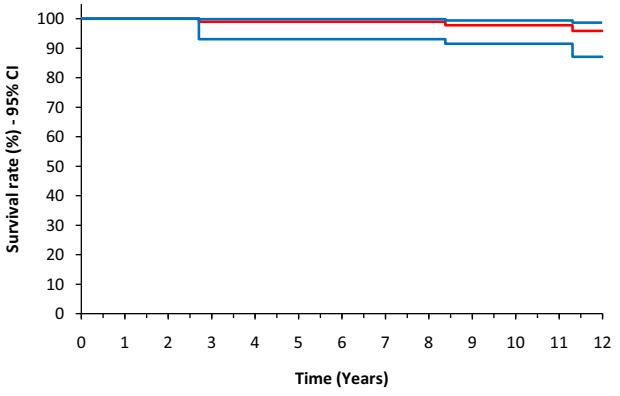

Figure 6 Survival curve for all causes of failure. Distribution of the survival function. Upper and lower 95% CI limits.

Complications

There were 13 cases of stiffness (11%) requiring manipulation under general anesthesia. Arthroscopic or open arthrolysis was not necessary. The rate of stiffness after total knee arthroplasty varies between 1—12% [4,5]. Postoperative stiffness can be due to factors such as the surgical technique (poor ligament balancing, oversized or poorly positioned implants, raising the articular line, anterior tibial slope, insufficient resection of posterior osteophytes) and preoperative factors associated with the patient (limited flexion, etiology, surgical history) or postoperative factors (infection, arthrofibrosis, complex regional pain syndrome, hererotopic ossifications) [5].

Control of postoperative pain is important to obtain correction flexion [6]. In this series the rate of manipulations under general anesthesia, can be explained, at least in part, by the use of intravenous analgesics for postoperative analgesia at that time. Since then, the development and use of postoperative peripheral nerve block recommended by the SFAR [7] has resulted in a decrease in these complications [8].

Functional and clinical evaluation

We observed a 10° loss in range of flexion. Knees with a preoperative flexion of 100° or less presented a non-significant increase in flexion, while knees with a preoperative flexion of more than 100° presented with a significant loss in flexion at 10 years of follow-up respectively. The preoperative difference between the two groups was significant but this difference disappeared at 10 years of follow-up. The increase in postoperative flexion for knees with poor preoperative range of motion, and the loss of postoperative flexion in knees with a good preoperative articular range of motion has been reported by Chiu et al. [9], and for PCL-retaining implants by Witvoet [10].

The knee score had statistically improved at five and 10 years of follow-up, with no deterioration between the two postoperative follow-up periods. The postoperative function score also statistically improved but there was deterioration between the 5- and 10-year follow-up results. These results are comparable to those in the literature [11—17] (Table 4).

Table 4 Review of the literature.

Publication	Prosthesis (cruciate-retaining)	Survivorship			Clinical results				Radiological results (percentage of knees exhibiting radiolucent lines)		
		5 years	10 years	12 years	Knee score		Function score		Femur	Tibia AP	Tibia lateral
					Preop	Postop	Preop	Postop			
Malkani, 1995 [11]	Kinematic-I		96%		33	79	46	64	≥ 38%	≥ 56%	≥ 47%
Weir, 1996 [28]	Kinematic	98.5%	92.1%	87.1%							
Abernethy, 1996 [29]	Kinematic	93.8%	87.9%								
Ansari, 1998 [30]	Kinematic	98%	96%								
Ewald, 1999 [12]	Kinematic-I				42	82	37	68	30%	40%	
Buehler, 2000 [13]	Press-Fit Condylar		93.4% at 9 years			96		68	36%	24%	
Van Loon, 2000 [14]	Kinematic	94.7%	89.5%	87.5%	44	89		49	23%	14%	
Gill, 2001 [15]	Kinematic	99.4%	98.2%	97.5%	36	90	44	51	4.5%	8.3%	
Berger, 2001 [20]	Miller-Galante II	100%	100%						11%	13%	1.4%
Laskin, 2001 [21]	Genesis		96%						0%	12%	
Chen, 2001 [36]	Genesis I		97%								
Fetzer, 2002 [16]	Press-Fit Condylar	100%	100%	93.3%	33	92	56	79	≥ 32%	≥ 40%	≥ 33%
Khaw, 2002 [32]	Press-Fit Condylar	97.8%	95.3%	95.3%							
Dixon, 2005 [31]	Press-Fit Condylar	100%	99%	96.8%							
Bourne, 2007 [17]	Genesis II			96%	38	91	47	64			
Attar, 2008 [33]	Press-Fit Condylar	97.4%	91.3%	90.2%							
Barrington, 2009 [37]	NexGen	99%	97%			94		75			
Schwartz, 2010 [38]	NexGen	98,7%	97,7%						12,7%		
This study	EUROP	99%	97.8%	95.8%	31	88	40	80	56%	49%	33%

Radiological evaluation

At 10 years of follow-up, 93% of the radiolucencies were 1 mm or less. All implants had a radiological score of 4 or less, indicating that the lesions were non-significant. The cause of the development of radiolucent lines, which often occurs early after surgery, is multifactorial. [18,19]. Radiolucencies are usually due to defective penetration of cement into sclerotic bone [19]. The one-stage cementing technique of both sides used in our series could favor a greater number of radiolucencies, compared to a two-phase cementing technique [18].

The size of the radiolucencies remained stable over time since the amount of PE wear was low. [19]. At 10 years of follow-up, 56% of the femurs had radiolucencies, as well as 49% and 33% of the tibias on AP view and lateral view X-rays respectively. Long-term studies of PCL-retaining cemented prostheses have shown that the rate of radiolucencies varied in published series between 0 and 38% for condyles, and 8 and 56% for tibial bases [11—16,20,21] (Table 4).

Wear of polyethylene (PE) liners is multifactorial [22]. Certain studies have suggested that the lack of congruence of non-anatomical implants, such as those used in our series, can increase contact strains and accelerate PE wear [23,24]. Although we did not measure wear of the PE liner we evaluated the frequency of osteolyses, as PE wear is the main cause of the development of osteolysis in cemented and cementless implants. This phenomenon occurred in 0—30% of cases in the published series and 0—16% of cemented TKA [22] (11% in our series).

Implant survival

The rate of implant survival for the EUROP prosthesis was 99% at five years, 97.8% at 10 years and 95.8% at 12 years of follow-up. Our results are comparable to those in the literature, which report an implant survival rate of 85%—95% [11,25—27]. Rand et al. reviewed 11606 primary TKA placed at the Mayo Clinic between 1978—2000, and found a global survival rate of 96% at five years and 91% at 10 years [26]. Furnes et al. reviewed primary cemented TKA at the Norwegian Registry of Arthroplasties and reported a survival rate of 92% at 10 years [27].

Several parameters can influence the TKA survival rate: the type of implant, the type of fixation (cemented or cementless) the characteristics of the study population (age, sex, level of activity), as well as the surgical technique (quality of placement, precision of bone incisions) [26]. Our study presented a homogenous cohort of cemented cruciate-retaining TKA with a single surgeon whose results were comparable to those in the literature. The studies performed on cemented cruciate-retaining TKA have shown a similar survival rate at 10 years of follow-up (Table 4): between 88—98% for kinematic implants [11,14,15,28—30], 91—100% in PFC [16,31—34], 99% in AGC [35], more than 96% for the Genesis implant [17,21,36], and 97% for the NexGen [37,38].

Conclusion

This monocentric prospective study of 121 EUROP TKA confirms the good clinical and radiological results of fixed bearing tibial PCL-retaining implants when the indications are respected. The use of this type of implant responds to precise preoperative clinical and radiological criteria, as well as the anatomical criteria of an intact preoperative central pivot. With three cases of revision at 12 years, implant survival was 98% at 10 years and 96% at 12 years. These results are comparable to those reported in the literature. This study will be continued to obtain an evaluation at 15 years of follow-up.

Disclosure of interest

A. Mouttet: No conflict of interest.
M-L. Louis: No conflict of interest.
V. Sourdet: Salaried employee at EUROS.

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